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Preliminary report on the herpetofaunal diversity of Batu Hampar Recreational Forest, Kedah, Malaysia

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Abstract

Batu Hampar Recreational Forest (BHRF) is a lowland dipterocarp forest located in the northwestern region of Peninsular Malaysia and has not been surveyed for its herpetofauna until now. A preliminary survey of the herpetofaunal diversity of BHRF was conducted from September 2018 to February 2019 resulting in 103 individuals (37 species) of amphibians and reptiles found. This includes 14 species of frogs from six families and 10 genera; 14 species of lizards from four families and 11 genera; eight species of snakes from five families and eight genera; and one species of freshwater turtle. From these results, Batu Hampar Recreational Forest has a high herpetofaunal diversity with a Simpson's Index of Diversity of 0.869 and a Shannon-Wiener Diversity Index of 2.930. In the future, additional surveys over longer periods of time should be conducted at BHRF to produce a more complete checklist.

Keywords

Amphibians, reptiles, checklist, herpetology, lowland rainforest

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Introduction

Peninsular Malaysia is located near the equator and has a near constant climate, which is warm and humid, throughout the year (Marshall Cavendish Corporation 2007). These warm, humid conditions provide an excellent environment for amphibians and reptiles to flourish, resulting in high species diversity (Bickford et al. 2010). Many surveys and expeditions have been conducted in Malaysia, and various publications on Malaysian herpetofauna have been published. These include Berry (1975), Denzer and Manthey (1991), Chan-ard et al. (1999), Grismer et al. (2001, 2004, 2006), Lim et al. (2002), Chan et al. (2009a, 2009b, 2009c, 2010a, 2010b, 2010c, 2019), Grismer (2011a, 2011b), Ibrahim et al. (2012), Zakaria et al. (2014), Sumarli et al. (2015), and Haas et al. (2018).

Northwestern Peninsular Malaysia comprises of the states of Perlis, Kedah, Penang, and Perak. There are a few prominent locations in northwestern Peninsular Malaysia where new species of amphibians and reptiles

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continue to be discovered and described, such as Penang Hill, Bukit Larut, and Pulau Langkawi. Some notable discoveries from this region recently include *Larutia penangensis*, the first limbless lizard found in Peninsular Malaysia (Grismer et al. 2011), *Hemiphyllodactylus cicak* from Penang Hill (Cobos et al. 2016), *Lycodon cavernicolus* from a limestone cave in Perlis (Grismer et al. 2014), and *Bronchocela shenlong* from Bukit Larut, Perak (Grismer et al. 2015a). Besides that, many new species were also described from Kedah, including *B. rayaensis*, *Cnemaspis mahsuriae*, *C. tubaensis*, and *Cyrtodactylus dayangbuntingensis* from the Langkawi Archipelago (Grismer et al. 2015a, 2015b; Quah et al. 2019, 2020a), and *Abavorana nazgul* from Gunung Jerai (Quah et al. 2017). Some of these species are endemic to a specific location in the northwestern region of Peninsular Malaysia. This demonstrates that the northwestern region of Peninsular Malaysia is an important area for herpetofauna diversity, as it harbours many endemic species of amphibians and reptiles.

Herpetofaunal surveys and published checklists are important in determining the geographic distribution of species and in their conservation. Therefore, herpetofauna surveys should be conducted in order to obtain up-to-date checklists of different areas, especially those areas that have not been surveyed before. The main objective of this study is to record the herpetofaunal assemblage at Batu Hampar Recreational Forest, which has never been surveyed. The second objective is to compare the herpetofaunal diversity of Batu Hampar Recreational Forest with that of other areas in the northwestern region of Peninsular Malaysia.

Study Area

The study area is at Batu Hampar Recreational Forest (05.1966°N, 100.5827°E) which is located at Air Putih, Serdang, Kedah, at an elevation of 40 m above sea level (a.s.l.) (Google Maps 2018) (Fig. 1). The vegetation in the area is composed of lowland dipterocarp forest (Azhar et al. 2015), where the dominant trees are those from the family Dipterocarpaceae. It is surrounded by oil palm and rubber plantations and a soon-to-be planted black pepper plantation. There is a dam at BHRF and waterfalls are present (Fig. 2A). There are puddles at the side of the forest trail near to the entrance and there is a stream along the forest trail which leads to the oil palm plantation (Fig. 2B–E). There are also buildings beside the parking area at the entrance.

Methods

Field surveys were conducted twice a month for six months from September 2018 to February 2019. Collections were focused along forest trails and the stream. Active surveys were carried out by day and night searches and included chance encounters (road kills). Specimens were caught by hand or with snake tongs or a hook for venomous species. Specimens that could not be collected were visually identified with a photo voucher for confirmation. Representative samples of each species were collected and photographed prior to preservation. Specimen collection was done with the permission of the Department of Wildlife and National Parks, Peninsular Malaysia.

Following euthanization with Ethyl 3-aminobenzoate methanesulfonate ($C_9H_{11}NO_2.CH_4O_3S$), also known as Tricaine, liver samples were taken and stored in 100% undenatured ethanol. Specimens were then fixed in 10% formalin and later transferred into 70% denatured ethanol for storage. Voucher material and photographs were deposited at the School of Biological Sciences, Universiti Sains Malaysia (specimen code USMHC).

The morphometric measurements of the specimen were taken, which included the snout–vent length (SVL) and tail length (TL). The identification of all collected specimens were confirmed by consulting Taylor (1962a), Berry (1975), Tweedie (1983), Lim and Das (1999), Auliya (2007), Grismer (2011a, 2011b), and Das (2015). A checklist of the amphibians and reptiles recorded were compiled and compared with that of other nearby locations, which included Bukit Panchor State Park (BPSP) (Quah et al. 2013), Lata Bukit Hijau Recreational Forest (LBHRF) (Shahriza et al. 2011; Shahriza and Ibrahim 2014b), Bukit Perangin Forest Reserve (BPFR) (Ibrahim et al. 2012), Ulu Paip Pecreational Forest (UPRF) (Shahriza and Ibrahim 2014a), Bubu Permanent Forest Reserve (BBPFR) (Ibrahim et al. 2011), and Bukit Jana

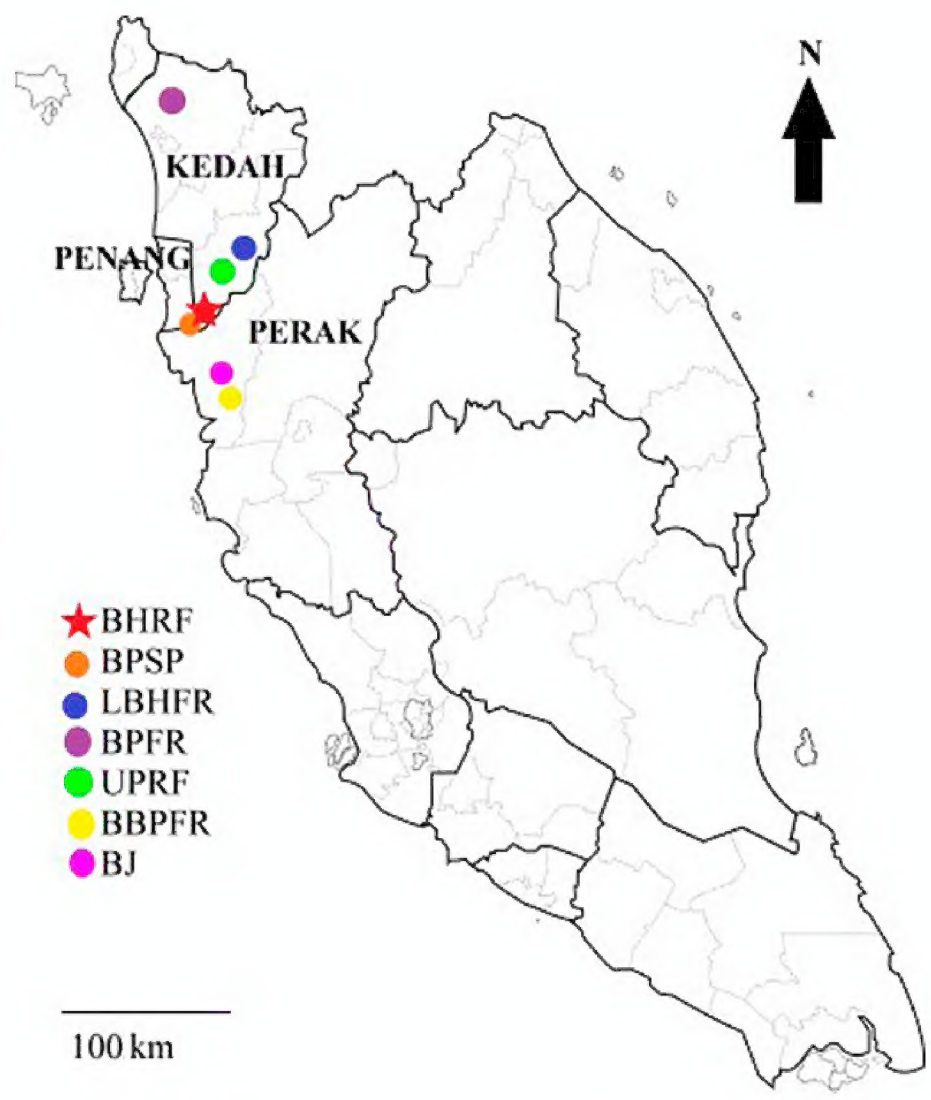

Figure 1. Map of Peninsular Malaysia showing the location of Batu Hampar Recreational Forest (BHRF), Bukit Panchor State Park (BPSP), Lata Bukit Hijau Forest Reserve (LBHFR), Bukit Perangin Forest Reserve (BPFR), Ulu Paip Recreational Forest (UPRF), Bubu Permanent Forest Reserve (BBPFR) and Bukit Jana (BJ).

Figure 2. Batu Hampar Recreational Forest habitats. **A.** Waterfall. **B.** Puddle at the side of forest trail. **C.** Forest trail. **D.** Stream along forest trail. **E.** Stream beside oil palm plantation.

(BJ) (Shahriza and Ibrahim 2012). The species diversity of herpetofauna at Batu Hampar Recreational Forest was analysed using Multi-Variate Statistical Package (MVSP), which include the Simpson's Index of Diversity (D), Shannon-Wiener Diversity Index (H), and species evenness index.

Results

In this study, 14 species of frogs from six families and 10 genera, 14 species of lizards from four families and 11 genera, eight species of snakes from five families and eight genera, and one species of freshwater turtle were recorded from Batu Hampar Recreational Forest.

Amphibians

Family Bufonidae

***Ingerophrynus parvus* (Boulenger, 1887a)**
Figure 3A

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 3 ♂, USMHC 2431–2433.

Identification and natural history. Three adult males (USMHC 2431, SVL 33 mm; USMHC 2432, SVL 32 mm; USMHC 2433, SVL 38 mm) matched Berry's (1975) and Grismer's (2011a) description in having stout, medium-sized bodies; head as wide as body; short and

rounded snout; two parallel parietal bony ridges between eyes; one short supratympanic crest; oval parotoid glands; moderately sized eyes; distinct tympanum up to 3/4 diameter of eye; short and not overly robust limbs; rounded digits with moderately webbed toes; first finger longer than second; subarticular tubercles present on fingers and toes; a large outer metacarpal tubercle; a small inner metacarpal tubercle; a prominent inner metatarsal tubercle; a prominent outer metatarsal tubercle; rough warty skin; paired and dark paravertebral markings on dorsum; limbs and vertebral blotches light pinkish; single dark band on thigh and foreleg which becomes contiguous when the knee is flexed; belly light coloured and chest lightly spotted. All specimens were found along puddles beside the trail in disturbed areas near to the entrance at night.

***Phrynoidis asper* (Gravenhorst, 1829)**
Figure 3B

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 8.X.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2479.

Identification and natural history. One adult male (SVL 108 mm) matched Berry's (1975) and Grismer's (2011a) description in having a stout body; obtuse snout; a thick supratympanic bony ridge which separates parotoid gland and eyelid; oval parotoid gland, moderately sized eyes; distinct tympanum ⅓ diameter of eye; stout limbs; bulbous tips of digits; first finger slightly longer than second; large subarticular tubercles on fingers; supernumerary metacarpal tubercles; conspicuous subarticular tubercles on toes; two metatarsal tubercles where the outer is smaller than the inner; completely webbed toes except toe four; rough and warty skin; dark brown dorsum and light-coloured belly and chest. The specimen was found calling along stream beside the trail at night.

Family Dicroglossidae

***Fejervarya limnocharis* (Gravenhorst, 1829)**
Figure 3C

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2438, 1 ♀, USMHC 2439.

Identification and natural history. One adult male (USMHC 2438, SVL 42 mm) and one adult female (USMHC 2439, SVL 49 mm) matched Berry's (1975) description in having a moderate head; pointed snout; distinct tympanum approximately 3/5 diameter of eye; blunt finger tips; pointed toe tips; first finger longer than second; deeply excised toe webbing with at least one phalanx of each toe free; three phalanges of fourth toe free; an oval, inner metatarsal tubercle; a small outer metatarsal tubercle; warty skin on dorsum where the warts confluent into irregular, longitudinal folds; a supratympanic fold; brownish dorsum with darker patches and a yellow vertebral stripe; back of thigh yellow; dark cross-bars on limbs; dark bars on lips and white venter. Both specimens were found around puddles by trail at night.

***Limnonectes blythii* (Boulenger, 1920)**
Figure 3D

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♀, USMHC 2440, 1 ♂, USMHC 2441.

Identification and natural history. One adult female (USMHC 2440, SVL 68 mm) and one adult male (USMHC 2441, SVL 78 mm) matched Grismer's (2011a) description in having stout bodies; thick and stocky limbs; broad head rounding off into a pointed snout; moderate eyes; distinct tympanum 1/4–2/3 diameter of eye; toes fully webbed; low tubercles scattered on the generally smooth skin; brown bands on lip; a supratympanic fold; dark brown dorsum and lighter venter. Both specimens were found along stream by trail at night.

***Limnonectes deinodon* Dehling, 2014**
Figure 3E

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2442, 2 ♀, USMHC 2443–2444 • same locality; 24.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 unsexed, USMHC 2454.

Identification and natural history. One adult male (USMHC 2442, SVL 54 mm), two adult females (USMHC 2443, SVL 53 mm; USMHC 2444, SVL 44 mm) and another unsexed individual (USMHC 2454, SVL 33 mm) matched Dehling's (2014) diagnosis in having sturdy bodies and limbs; large head; moderately large eyes which are directed anterolaterally and protruding; tympanum hidden; rounded finger tips; disk on toe tips without circum-marginal groove; subarticular tubercles present on fingers and toes; large and elongated inner metatarsal tubercle; smaller outer metatarsal tubercle; reduced toe webbing which does not reach the toe disk and does not extend beyond the penultimate subarticular tubercle on Toe IV; dorsum corrugated and scattered with enlarged subconical tubercles; strong, dark greyish-brown supratympanic fold from eye to edge of forelimb insertion; large dark greyish brown vertical bars in labial region; light brown dorsum with dark brown markings which include an interorbital bar; an inverted V-shaped marking between shoulders; large spots on back and dark cross-bars on limbs; smooth venter; greyish-white chest and abdomen with light brown speckles on chest; and underside of limbs cream with light brown speckles. All specimens were found along rivulets by the forest trail at night.

***Limnonectes hascheanus* (Stoliczka, 1870)**
Figure 3F

Materials examined. MALAYSIA – **Kedah** • Batu

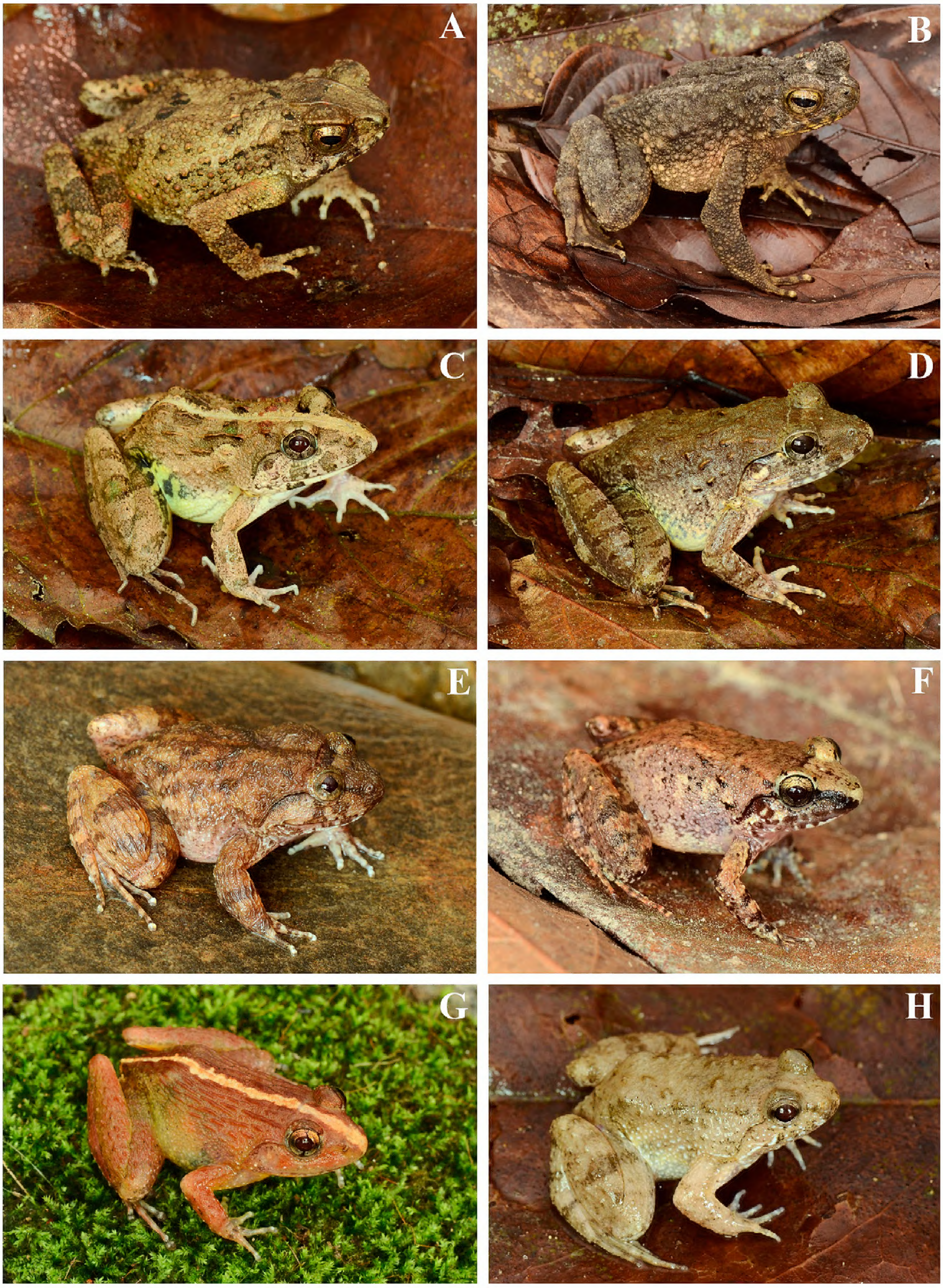

Figure 3. Frogs from families Bufonidae and Dicroglossidae. **A.** *Ingerophrynus parvus*. **B.** *Phrynoidis asper*. **C.** *Fejervarya limnocharis*. **D.** *Limnonectes blythii*. **E.** *Limnonectes deinodon*. **F.** *Limnonectes hascheanus*. **G.** Female *Limnonectes plicatellus*. **H.** *Phrynoglossus martensii*.

Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 24.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2455.

Identification and natural history. One adult male (USMHC 2455, SVL 25 mm) matched Berry's (1975) and Grismer's (2011a) description in having a small and moderately-built body; thick and stocky limbs; broad head; rounded snout; distinct tympanum about 2/3 diameter of eye; small disks on finger and toe tips; first finger as long as second; moderate subarticular tubercles on fingers and toes; a large inner metatarsal tubercle; no outer metatarsal tubercles; small flat warts on skin; absence of distinct dorsolateral fold; strong supratympanic fold from eye to shoulder; pale brown dorsum with small darker spots; a dark crossbar between the eyes; a blackish streak passing through the eye on each side of the head; dark brown vertical bars on lips; regular dark cross-bands on limbs; white venter and throat spotted with brown. The specimen was found in leaf litter by trail, calling at night.

***Limnonectes plicatellus* (Stoliczka, 1873)**
Figure 3G

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♀, USMHC 2445 • same locality; 27.XI.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♀, USMHC 2488.

Identification and natural history. Two adult females (USMHC 2445, SVL 34 mm; USMHC 2488, SVL 32 mm) matched Berry's (1975) description in having large head; bluntly pointed snout; distinct tympanum; finger and toe tips dilated into small but distinct disk without circum-marginal grooves; first finger slightly longer than second; toes moderately webbed; well-developed subarticular tubercles; elongated inner metatarsal tubercle; no outer metatarsal tubercle; dorsal skin with many distinct and discontinuous longitudinal folds; strong supratympanic fold; tubercles on upper eyelid; bronze dorsum and lemon yellow venter. USMHC 2445 was found along puddles by trail and USMHC 2488 was found along seepage by trail at night. A male of the species with the distinctive horn-like protrusion on the head was observed on 23 September 2018 but escaped before it could be collected.

***Phrynoglossus martensii* (Peters, 1867)**
Figure 3H

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 2 ♂, USMHC 2447–2448.

Identification and natural history. Two adult males (USMHC 2447, SVL 24 mm; USMHC 2448, SVL 25 mm) matched Taylor's (1962a) diagnosis in having a flattened head; tympanum covered with skin; first finger longer than second; distinct inner and outer metacarpal tubercles; disk on toe tips; toes completely webbed; a supratympanic fold from eye to near arm; large inner metatarsal tubercle; no outer metatarsal tubercle; brownish-grey dorsum scattered with small tubercles; lighter spots on tip of snout and along upper lip; smooth venter yellowish-white to flesh-white; indistinctly barred arms and distinct brown bars on legs. Both specimens were found along puddles by trail at night.

Family Megophryidae

***Leptobrachium hendricksoni* Taylor, 1962a**
Figure 4A

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 24.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2456.

Identification and natural history. One adult male (USMHC 2456, SVL 41 mm) matched Taylor's (1962a) and Berry's (1975) description in having broad head; distinct tympanum 1/2 diameter of eye; rounded finger tips; subequal first and second fingers; shorter fourth finger; longer third finger; two round and large metacarpal tubercles where the inner is slightly larger than outer; an oval inner metatarsal tubercle; no outer metatarsal tubercles; a supratympanic fold from eye to axilla; smooth skin; lavender brown dorsum; cream venter speckled with black; black dorsal bars on limbs and bright orange iris in life. The specimen was found in leaf litter by trail at night.

Family Microhylidae

***Microhyla heymonsi* Vogt, 1911**
Figure 4B

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2449, 1 ♀, USMHC 2450.

Identification and natural history. One adult male (USMHC 2449, SVL 19 mm) and one adult female (USMHC 2450, SVL 21 mm) matched Berry's (1975) description in having rounded snout; hidden tympanum; small but distinct disks on finger and toe tips; circum-marginal groove present on toe disk; first finger shorter than second; distinct subarticular tubercles; two small metatarsal tubercles; toes webbed at base; smooth dorsum and venter; a black lateral stripe extending from snout tip to groin, covering the sides of the head and flanks; a fine white vertebral line from snout to vent with a small black mark on the middle of the back on each side of the line; smaller marks between shoulders; black anal region, front of thighs and lower surfaces of tarsus; ill-defined cross-bars on limbs and dirty white venter. The specimens were found along puddles by trail at night.

***Microhyla mukhlesuri* Hasan, Islam, Kuramoto, Kurabayashi & Sumida, 2014**
Figure 4C

Materials examined. MALAYSIA – **Kedah** • Batu

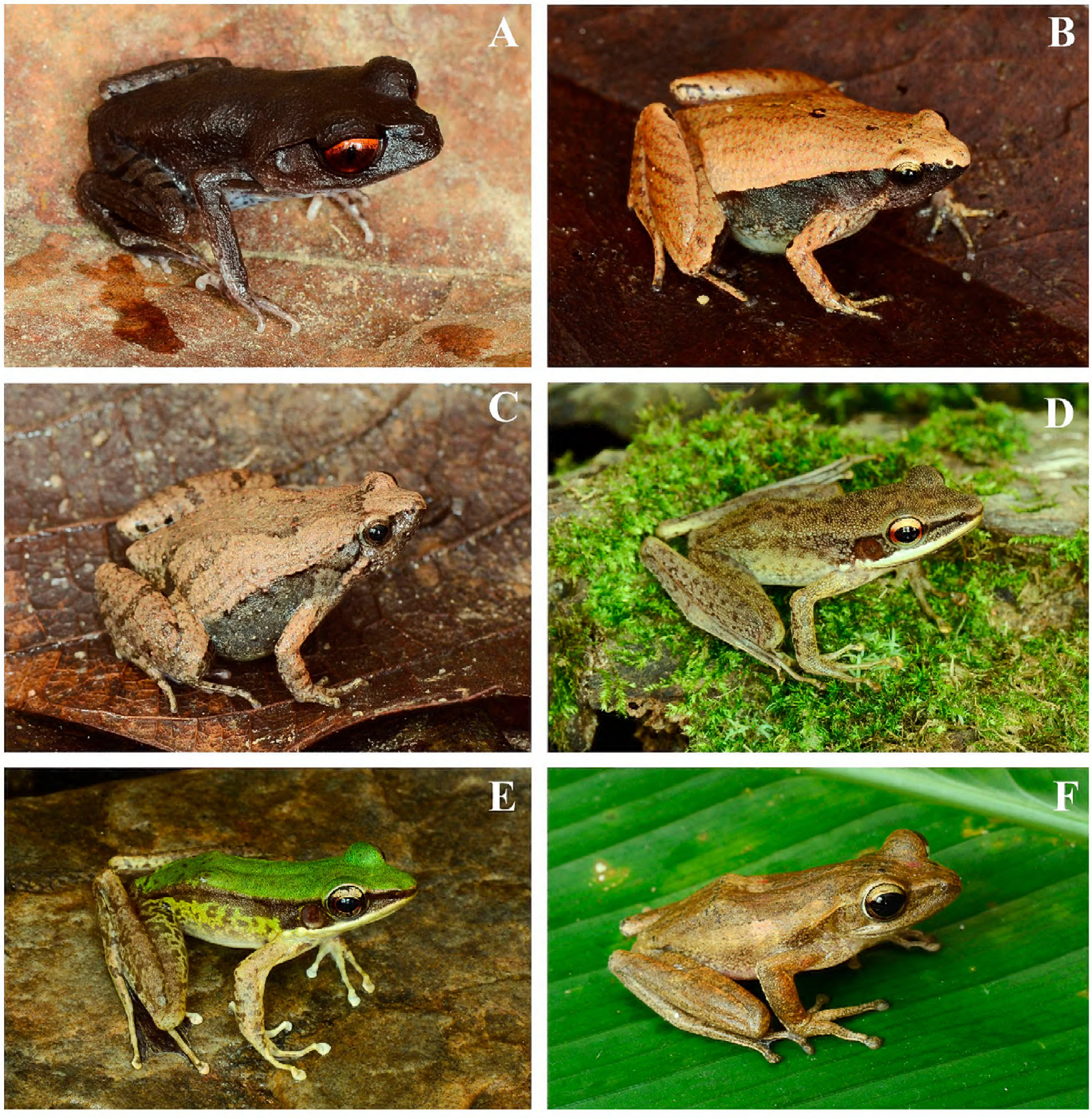

Figure 4. Frogs from families Megophryidae, Microhylidae, Ranidae, and Rhacophoridae. **A.** *Leptobrachium hendricksoni* (USMHC 2457). **B.** *Microhyla heymonsi*. **C.** *Microhyla mukhlesuri* (USMHC 2457). **D.** *Hylarana labialis*. **E.** *Odorrana hosii*. **F.** *Polypedates leucomystax*.

Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 24.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♀, USMHC 2456.

Identification and natural history. One adult female (USMHC 2456, SVL 26 mm) matched Hasan et al.'s (2014) and Poyarkov et al.'s (2019) description in having rounded snout; hidden tympanum; first finger shorter than second; fingers free and slender; tips of fingers and toes not widened; slight rudimentary webbing on toe; distinct subarticular tubercles on fingers and toes; two small but prominent, subequal metatarsal tubercles; smooth skin; greyish-olive dorsum with distinct X-shaped marking on the back, beginning between the eyes and widening as it extends to the posterior of the body with wavy dusky lines along each sides of the marking; dark band present along sides of head and body; dark cross bars on limbs; inverse U-shaped marking on the anus; greyish throat with faint white spots and an immaculate grey belly. The specimen was found in leaf litter by trail at night.

Family Ranidae

***Hylarana labialis* (Boulenger, 1887a)**

Figure 4D

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2434, 1 ♀, USMHC 2435.

Identification and natural history. One adult male (USMHC 2434, SVL 36 mm) and one adult female

(USMHC 2435, SVL 36 mm) matched Boulenger's (1887a) and Grismer's (2011a) description in having a head longer than broad; long snout; distinct tympanum about ¾ diameter of eye; toes fully webbed, except fourth toe which is webbed to distal subarticular tubercle; large disk on finger tips; smaller disk on toe tips; subarticular tubercles present on fingers and toes; two small metatarsal tubercles, the outer indistinct; finely granulated dorsum which ranges from green to brown and with indistinct darker spots; a white stripe along upper lip; chestnut-brown tympanum; slender hind limb with more or less distinct dark cross-bands; brown reticulation on hind side of thighs and the side of hind limbs; and venter smooth with brown spots on the throat and pectoral region. Both specimens were found along the stream by forest trail at night.

***Odorrana hosii* (Boulenger, 1891a)**
Figure 4E

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 2 ♂, USMHC 2436–2437.

Identification and natural history. Two adult males (USMHC 2436, SVL 52 mm; USMHC 2437, SVL 49 mm) matched Berry's (1975) and Grismer's (2011a) description in having a moderately slender body; large eyes; distinct tympanum ¾ diameter of eye; muscular, long and slender limbs; round disks with circum-marginal groove at tip of digits; fully webbed toes; oval inner metatarsal tubercle; no outer metatarsal tubercle; a weak dorsolateral fold; supratympanic fold absent; dorsum is finely pebbled; upper lip white; dorsal surface of limbs brownish with blackish cross-bands; body colouration variable, various mixtures of green and brown on dorsum and flanks, and belly greyish. Both specimens were found along the stream at night perched on the rocks and vegetation.

Family Rhacophoridae

***Polypedates leucomystax* (Gravenhorst, 1829)**
Figure 4F

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2446 • same locality; 24.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2458.

Identification and natural history. Two adult males (USMHC 2446, SVL 51 mm; USMHC 2458, SVL 46 mm) matched Berry's (1975) and Grismer's (2011a) description in having a slender, medium-sized body; broad head; rounded and projecting snout; distinct tympanum; long, slender hind limbs; round disks with circum-marginal grooves on the tips of digits; fully webbed toes; lack of webbing on fingers; an oval inner metatarsal tubercle; no outer metatarsal tubercle; supratympanic fold present from eye to shoulder; dark longitudinal line below supratympanic fold; smooth skin; variable colour pattern from light to dark tan, with or without four dark, narrow vertebral stripes; dark cross-bars on limbs and whitish belly and chest. Both specimens were found around puddles by trail at night.

SQUAMATA
LIZARDS

Family Agamidae

***Aphaniotis fusca* (Peters, 1864)**
Figure 5A

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2459, 1 ♀, USMHC 2460 • same locality; 11.II.2019; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2556.

Identification and natural history. Two adult males (USMHC 2459, SVL 45 mm, TL 94 mm; USMHC 2556, SVL 52 mm, TL 105 mm) and one adult female (USMHC 2460, SVL 37 mm, TL 73 mm) matched Das's (2015) and Grismer's (2011a, 2011b) diagnosis in having a slender and compressed body; rounded snout; lacking a high nuchal crest; tympanum covered by scales making it only slightly visible at best; long and thin limbs; unmodified digits; Toe V longer than Toe I; long and slender tail; small dorsal scales with larger scattered scales; bright blue gums; brownish-olive dorsum and pale olive-brown venter. All specimens were found sleeping on low vegetation along trail by stream at night.

***Bronchocela cristatella* (Kuhl, 1820)**
Figure 5B

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 8.X.2018; Evan S. H. Quah, Hong Zijia leg.; ♂, USMHC 2480 • same locality; 19.X.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♀, USMHC 2486.

Identification and natural history. One adult male (USMHC 2480, SVL 109 mm, TL 352 mm) and one adult female (USMHC 2486, SVL 95 mm, TL 300 mm) matched Das's (2015), Grismer's (2011b) and Grismer et al.'s (2015) diagnosis in having slender body; long head; dorsal crest present; naked and black tympanum; unequal and smooth scales; 8–10 supralabials; 7–12 infralabials; 53–120 midbody scale rows; 27–35 lamellae under Toe IV; bright green dorsum that is changeable to brown when stressed; lack of white stripe on lower lip; lack of postfemoral red stripe; yellowish-green venter; anterior half of tail green with distinct grey bands and posterior half of tail brownish-grey. USMHC 2480 was found sleeping on tree by waterfall at night while USMHC 2480 was found sleeping on fern along trail at night.

Figure 5. Lizards from families Agamidae, Gekkonidae, and Varanidae. **A.** *Aphaniotis fusca*. **B.** *Bronchocela cristatella*. **C.** *Gonocephalus grandis*. **D.** *Cyrtodactylus consobrinus* (USMHC 2471). **E.** *Gekko kuhli* (USMHC 2558). **F.** *Varanus salvator*.

Calotes versicolor (Daudin, 1802a)

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2451, 1 juvenile, USMHC 2452.

Identification and natural history. One adult male (USMHC 2451, SVL 74 mm, TL 218 mm) and one juvenile (USMHC 2452, SVL 57 mm, TL 166 mm) matched Das's (2015), Grismer's (2011b) and Pal et al.'s (2018) diagnosis in having a robust and compressed body; large head; well-developed nuchal and dorsal crest; lack of postorbital spine; body scales point backward and upward; 10–12 supralabials; 9–11 infralabials; 38–50 mid-body scale rows; greyish-brown dorsum with irregular

darker patches on the flanks and irregular dark crossbar on legs. Both specimens were found sleeping on vegetation along forest trail at night.

***Gonocephalus grandis* (Gray, 1845)**
Figure 5C

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 2 ♀, USMHC 2461, 2557, 1 juvenile, USMHC 2462.

Identification and natural history. Two adult females (USMHC 2461, SVL 93 mm, TL 247 mm; USMHC 2557, SVL 96 mm, TL 248 mm) and one juvenile (USMHC 2462, SVL 81 mm, TL 166 mm) matched Das's (2015) and Grismer's (2011a, 2011b) diagnosis in having robust and laterally compressed bodies; naked tympanum and unmodified digits. Female and juvenile males lacking dorsal crest; greenish-brown dorsum with anteriorly-projecting oblique bands; wide and dark postorbital stripe extending to above shoulder and whitish throat with faint streaking. All specimens were found sleeping on vegetation at night usually close to proximity of the stream. Specimens were also observed during the daytime perched on the trunks of trees and other vegetation close to the stream.

Family Gekkonidae

***Cyrtodactylus consobrinus* (Peters, 1871)**
Figure 5D

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 24.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♀, USMHC 2471 • same locality; 19.X.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♀, USMHC 2487.

Identification and natural history. Two adult females (USMHC 2471, SVL 112 mm, TL 137 mm; USMHC 2487, SVL 125 mm, TL 138 mm) matched Das's (2015) and Grismer's (2011b) diagnosis in having robust body; granular scales on dorsal surface interspersed with tubercles; naked tympanum; 10–16 supralabials; 9–13 infralabials; 58–70 midventrals; thin white reticulum on head; dark chocolate-brown dorsum with thin, white, zig-zag-shaped, transverse bars; white bands on tail; and cream pectoral and abdominal regions. USMHC 2471 was found on rock wall along trail, while USMHC 2487 was found on buttress roots of tree along trail at night.

***Gehyra mutilata* (Wiegmann, 1834b)**

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2463, 1 ♀, USMHC 2464.

Identification and natural history. One adult male (USMHC 2463, SVL 56 mm, TL 45 mm) and one adult female (USMHC 2464, SVL 55 mm, TL 42 mm) matched Das's (2015) and Grismer's (2011a, 2011b) diagnosis in having robust body; large head; naked tympanum; vertical pupil; delicate skin; flattened tail that widens at base; large and flat scales on venter and tail; short and wide limbs; claw on inner digit absent; slightly webbed hands and feet; expanded subdigital lamellae; pale and translucent grey dorsum and pale pink venter. Both specimens were found on the walls of buildings in the area at night.

***Gekko kuhli* (Stejneger, 1902)**
Figure 5E

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 11.II.2019; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2558.

Identification and natural history. One adult male (SVL 68 mm, TL 62 mm) matched Das's (2015) and Grismer's (2011a, 2011b) description in having a robust body; large head; scattered tubercles on dorsum of body and tail; naked tympanum; vertical pupil; 11–15 supralabials; 10–12 infralabials; large fringe of skin extending from periphery of neck, body, hind limbs, and tail which is deeply crenulated along edge of tail and expanded on tip; short and wide limbs; extensively webbed hands and feet; expanded subdigital lamellae; dorsum greyish with wavy dark brown bands; dark, postorbital stripe extending onto shoulder region and unpatterned light yellow venter. The specimen was found on a tree trunk approximately 2 m off the ground sheltering under the fronds of a bird's-nest fern (*Asplenium nidus*) along trail at night.

***Gekko monarchus* (Schlegel, 1836)**

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 2 ♀, USMHC 2469–2470.

Identification and natural history. Two adult females (USMHC 2469, SVL 74 mm, TL 91 mm; USMHC 2470, SVL 76 mm, TL 84 mm) matched Das's (2015) and Grismer's (2011a, 2011b) diagnosis in having a robust body; large tuberculate scales on dorsal surface; naked tympanum; vertical pupil; 30–38 midventrals; inner digit's claw absent; expanded subdigital lamellae; greyish-brown dorsum with dark brown blotches and cream venter. Both specimens were found on the walls of buildings at night.

***Hemidactylus frenatus* Duméril & Bibron, 1836**

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 2 ♂, USMHC 2467–2468.

Identification and natural history. Two adult males (USMHC 2467, SVL 54 mm, TL 62 mm; USMHC 2468, SVL 50 mm, TL 51 mm) matched Das's (2015) and Grismer's (2011a) diagnosis in having a robust and slightly flattened body; short and stocky limbs; large head; naked tympanum; vertical pupil; 9–12 supralabials; 7–10 infralabials; segmented and tapering tail with rows

of spine-like tubercles on original tail; smooth dorsal scales; no webbing on fingers and toes; moderately expanded subdigital lamellae; 8–11 lamellae under Toe IV with 5–8 divided; greyish-brown dorsum and cream venter. Both specimens were found on the walls of buildings at night.

Hemidactylus murrayi **Gleadow, 1887**

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 2 ♀, USMHC 2465–2466.

Identification and natural history. Two adult females (USMHC 2465, SVL 60 mm, TL 74 mm; USMHC 2466, SVL 51 mm, TL 47 mm) matched Gleadow's (1887) and Lajmi et al.'s (2016) diagnosis in having a concaved forehead; verticle pupil; 10–12 supralabials; 9–10 infralabials; small granular scales and tubercles on dorsal surface; median groove on dorsal surface of tail; spine-like tubercles on each side of tail, which decrease in number and size towards the tip; enlarged subcaudal scales; scattered keeled tubercles on limbs; moderately dilated digits; well-developed first digits; 7–9 lamellae under Toe IV; grey dorsum with several dark bands and white venter. Both specimens were found on the walls of buildings at night.

Family Scincidae

Eutropis macularia **(Blyth, 1853)**

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2430.

Identification and natural history. One adult male (SVL 52 mm, TL 64 mm) matched Das's (2015) diagnosis in having slender body; short snout; well-developed limbs; 28–34 midbody scale rows; 12–17 lamellae under Toe IV; bronze-brown dorsum with darker spots; flanks darker than dorsum with white spots and venter cream. The specimen was uncovered in leaf litter along trail at night.

Eutropis multifasciata **(Kuhl, 1820)**

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 19.X.2018; Evan S. H. Quah, Hong Zijia leg.; 1 juvenile, USMHC 2484 • same locality; 27.XI.2018; Evan S. H. Quah, Hong Zijia leg.; 1 juvenile, USMHC 2489.

Identification and natural history. Two juveniles (USMHC 2484, SVL 57 mm, TL 97 mm; USMHC 2489, SVL 47 mm, TL 6 mm) matched Das's (2015) diagnosis in having robust body; short limbs; distinct head; short snout; small tympanum; large plate-like scales on head; 29–35 midbody scale rows; 17–23 lamellae under Toe IV; unmodified digits; bronze-brown dorsum and cream venter. USMHC 2484 was found in the midst of being eaten by a *Bungarus candidus* (USMHC 2483), which was found in leaf litter along trail at night. USMHC 2489 was found in leaf litter along trail and it detached its tail while it was being caught.

Sphenomorphus scotophilus **(Boulenger, 1900c)**

Remarks. The presence of this species in Batu Hampar Recreational Forest remains unconfirmed with voucher specimens. A specimen was observed crawling on a rock wall along a trail at night on 24 September 2018 but could not be caught or photographed.

Family Varanidae

Varanus salvator **(Laurenti, 1768)**

Figure 5F

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 25.X.2018; Evan S. H. Quah, Hong Zijia obs.

Identification and natural history. An individual matched Das's (2015) and Grismer's (2011a) diagnosis in having stout body; long neck; depressed snout; nostrils situated near the tip of snout; dark dorsum with yellow spots and yellowish venter. It was found sleeping at night under some vegetation in a shallow stream.

Family Colubridae

Boiga melanota **(Boulenger, 1896)**

Figure 6A

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia obs.; USMHC 2475 • same locality; 8.X.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2482.

Identification and natural history. One adult male (SVL 1015 mm, TL 259 mm) matched Tweedie's (1983) and Weinell et al.'s (2020) diagnosis in having a large, robust and laterally compressed body; head distinct from neck; short and rounded snout; single preocular; two postoculars; loreal present; eight supralabials, where the 3rd to 5th touches the eye; 11–12 infralabials; large eye; vertical pupil; smooth dorsals; 21 midbody scale rows; 202–253 ventrals; 89–118 paired subcaudals; anal scale entire; black dorsum with 21–46 yellow bands on body which do not meet mid-dorsally; labials and gular region yellow and venter grey. The specimen was found crawling on the ground along trail at night. Another specimen was observed crawling through low vegetation along stream bank at night on 23 September 2018 and a tail clipping was taken (USMHC 2475).

Gonyosoma oxycephalum **(Boie, 1827)**

Figure 6B

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 24.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2473.

Identification and natural history. One adult male (SVL 608 mm, TL 192 mm) matched Tweedie's (1983)

Figure 6. Snakes from families Colubridae, Elapidae, Homalopsidae, Pareidae, and Viperidae, and turtle from Family Trionychidae. **A.** *Boiga melanota*. **B.** *Gonyosoma oxycephalum* (USMHC 2473). **C.** *Oligodon purpurascens* (USMHC 2472). **D.** *Bungarus candidus*. **E.** *Homalopsis buccata*. **F.** *Aplopeltura boa* (USMHC 2481). **G.** Adult female *Tropidolaemus wagleri* (USMHC 2474). **H.** *Dogania subplana*.

and Das's (2015) diagnosis in having a slender, elongated and compressed body; head distinct from neck; elongated snout; single preocular; two postoculars; loreal present; 9–11 supralabials, where the 6th and 7th touches the eye; 12–14 infralabials; large eye; rounded pupil; long and tapering tail; smooth dorsals; 25 midbody scale rows; 230–263 ventrals; 120–157 paired subcaudals; anal scale divided; light green dorsum and throat; black stripe along sides of head, from nostril, across eye, to above level of upper jaw; grey to reddish-brown tail and yellowish venter. The specimen was found sleeping on tree 4 m off the ground at night.

***Oligodon purpurascens* (Schlegel, 1837b)**
Figure 6C

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2472.

Identification and natural history. One adult male (SVL 454 mm, TL 101 mm) matched Tweedie's (1983) and Das's (2015) diagnosis in having a robust and sub-cylindrical body; head short and indistinct from neck; 1–2 preoculars; 2–3 postoculars; loreal present; eight supralabials, where the 5th touches the eye; 8–9 infralabials; small eye; rounded pupil; smooth dorsals; 19 midbody scale rows; 160–210 ventrals; 40–60 paired subcaudals; anal scale entire; brownish-purple dorsum with wavy dark bands; dark chevron on forehead and pink venter with squarish-dark spots. The specimen was found crawling out from a hole among rocks by the stream along trail at night.

Family Elapidae

***Bungarus candidus* (Linnaeus, 1758)**
Figure 6D

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 23.IX.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2453 • same locality; 19.X.2018; Evan S. H. Quah, Hong Zijia leg.; 1 ♀, USMHC 2483.

Identification and natural history. One adult male (USMHC 2453, SVL 790 mm, TL 110 mm) and one adult female (USMHC 2483, SVL 792 mm, TL 70 mm) matched Tweedie's (1983) and Das's (2015) diagnosis in having a robust body; head indistinct from neck; single preocular; two postoculars; loreal absent; seven supralabials, where the 3rd and 4th touches the eye; seven infralabials; small eye; rounded pupil; short tail; smooth dorsals; 15 midbody scale rows; 194–237 ventrals; 37–56 single subcaudals; anal scale entire; black dorsum with broad white cross bars on body and tail, where the black interspaces are much wider than the white bands anteriorly, slightly wider or equal posteriorly and on the tail; white bands scattered with black spots; supralabials and venter white and immaculate and dark brown spots on subcaudals. USMHC 2453 was found crawling along puddle by trail while USMHC 2483 was found in the leaf litter along trail, eating a skink, *Eutropis multifasciata* (USMHC 2484) at night.

Family Homalopsidae

***Homalopsis buccata* (Linnaeus, 1758)**
Figure 6E

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 11.II.2019; Evan S. H. Quah, Hong Zijia leg.; 1 ♂, USMHC 2559.

Identification and natural history. One adult male (SVL 472 mm, TL 152 mm) matched Murphy et al.'s (2012) and Tweedie's (1983) diagnosis in having single loreal contacting upper labials 1–4; one postocular scale; one postsubocular scale; 10–12 supralabials which are separated from the eye by a row of subocular scales; ventral scale less than 166; 68–106 paired subcaudals; 33–40 midbody scale rows which are reduced to less than 30 posteriorly; dark-greyish-brown dorsum with complete and incomplete light crossbars which alternate along the body and are bordered with black; light and dark brown symmetrical markings on head; a triangular patch on the snout; a stripe running from near the snout through the eye to the jaw where it may join the dark colour of the neck; yellow ventrals with brown spots at the ends of every third to fifth ventral and the underside of tail mottled with brown. The specimen was found in the stream beside the oil palm plantation at night.

Family Pareidae

***Aplopeltura boa* (Boie, 1828)**
Figure 6F

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 8.X.2018; Evan S. H. Quah, Hong Zijia leg.; 1 juvenile, USMHC 2481.

Identification and natural history. One juvenile (SVL 197 mm, TL 95 mm) matched Tweedie's (1983) and Das's (2015) diagnosis in having a slender and laterally compressed body; short and rounded head, distinct from the neck; two preoculars; two postoculars; 2–3 loreals; 8–10 supralabials which are separated by a row of subocular scales from the eye; 11 infralabials; large eye, where the diameter of orbit is longer than snout length; smooth dorsals; 13 midbody scale rows; 148–191 ventrals; 88–131 undivided subcaudals; anal scale entire; greyish-brown dorsum; large cream spots on flanks; dark brown forehead; cream labials; cream patch under eye with dark subtriangular area and dark grey venter. The specimen was found crawling on ferns by trail at night.

Family Viperidae

***Calloselasma rhodostoma* (Kuhl, 1824)**

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 1.III.2018; Evan S. H. Quah obs.; LSUDPC 12666.

Identification and natural history. A specimen was found dead on the road leading into the parking lots of BHRF on 1 March 2018. Based on the colour pattern that is still visible, the specimen matched Tweedie's (1983) and Das's (2015) diagnosis in having reddish-brown or purplish-brown dorsum, dark brown subtriangular marks on each side and pinkish-cream venter.

***Tropidolaemus wagleri* (Boie, 1827)**
Figure 6G

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 22.IX.2018; Evan S. H. Quah, Hong Zijia obs.; 1 ♀, USMHC 2474 • same locality; 24.IX.2018; Evan S. H. Quah, Hong Zijia obs.; 1 ♂ • same locality; 8.X.2018; Evan S. H. Quah, Hong Zijia obs.; 3 ♀ • same locality; 19.X.2018, 27.X.2018; Evan S. H. Quah, Hong Zijia obs.; 1 ♀.

Identification and natural history. All individuals matched Das's (2015) and Grismer's (2011a) diagnosis in having a triangular head that is distinct from neck; black dorsum with yellow cross bars, head and body scattered with yellow spots in females. Males are smaller and green with white and red spots. One adult female was spotted coiled on a tree in the morning on 22 September 2018 and tail clipping was taken (USMHC 2474). A male was spotted on a tree 10 m off the ground beside the dam at night on 24 September 2018. Another three adult females were spotted coiled on vegetation and trees along trail at night on 8 October 2018. An adult female was spotted coiled on the same tree along the trail at night on 19 October and 27 November 2018.

TURTLES

Family Trionychidae

***Dogania subplana* (Geoffroy, 1809)**
Figure 6H

Materials examined. MALAYSIA – **Kedah** • Batu Hampar Recreational Forest; 05.1966°N, 100.5827°E; 40 m a.s.l.; 24.IX.2018; Evan S. H. Quah, Hong Zijia obs. • same locality; 8.X.2018; Evan S. H. Quah, Hong Zijia obs.

Identification and natural history. Two individuals matched Auliya's (2007) and Lim and Das's (1999) diagnosis in having carapace flat and oval with distinctly straight sides; large head with down-turned trunk-like snout; dark olive carapace with dark median stripe and cream plastron. An individual was found in the stream beside the oil palm plantation on 24 September 2018 and another was observed partially buried in the sand in the stream bed near waterfall on 8 October 2018.

Species diversity of Batu Hampar Recreational Forest. The Simpson's Index of Diversity (D) and Shannon-Wiener Diversity Index (H) for the herpetofauna at Batu Hampar Recreational Forest are 0.869 and 2.930, respectively, with a total of 103 individuals comprising of 37 species. Simpson's Index of Diversity (D) ranges from 0 to 1, and higher value indicate higher diversity. Similarly for the Shannon-Wiener Diversity Index (H), higher value indicates a higher diversity. Based on the Shannon-Wiener Diversity Index, species evenness index is calculated. The species evenness of herpetofauna at BHRF is 0.811, and a higher evenness index value shows higher species evenness. Thus, the herpetofaunal diversity in BHRF is considered quite high.

Comparison of herpetofaunal diversity between Batu Hampar Recreational Forest and other nearby locations. Based on published checklists from around the northwestern region of Peninsular Malaysia, Bukit Panchor State Park (BPSP) has the highest species richness (65 species; Quah et al. 2013), compared to other sampling sites: 37 species at BHRF; 53 species at Lata Bukit Hijau Recreational Forest (LBHRF) (Shahriza et al. 2011; Shahriza and Ibrahim 2014b); 30 species at Bukit Perangin Forest Reserve (BPFR) (Ibrahim et al. 2012); 21 species at Ulu Paip Recreational Forest (UPRF) (Shahriza and Ibrahim 2014a); 26 species at Bubu Permanent Forest Reserve (BBPFR) (Ibrahim et al. 2011); 24 species at Bukit Jana (BJ) (Shahriza and Ibrahim 2012) (Figs. 7, 8). Of the 14 species of frogs recorded from BHRF, 12 species (85.71%) are in common with BPSP (7.7 km from BHRF) and BJ (55.1 km from BHRF), nine (64.29%) with LBHRF (63.4 km from BHRF), UPRF (48.4 km from BHRF) and BBPFR (79.0 km from BHRF), and six (42.86%) with BPFR (160.0 km from BHRF) (Fig. 1; Table 1). On the other hand, BHRF shares 17 (77.27%) of reptile species in common with LBHRF, 12 (54.55%)

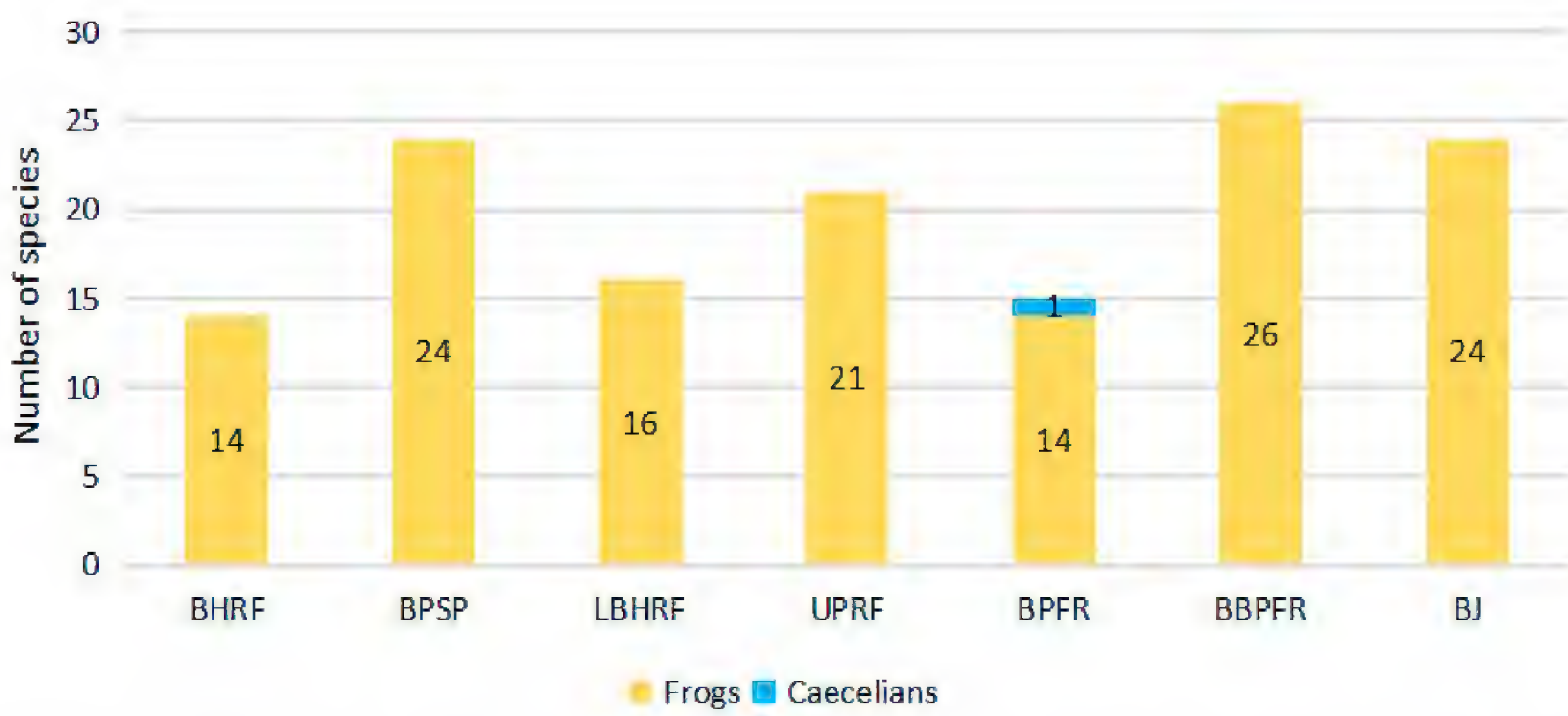

Figure 7. Number of amphibian species for different taxa (frogs and caecilians) recorded from BHRF, BPSP, LBHRF, UPRF, BPFR, BBPFR, and BJ.

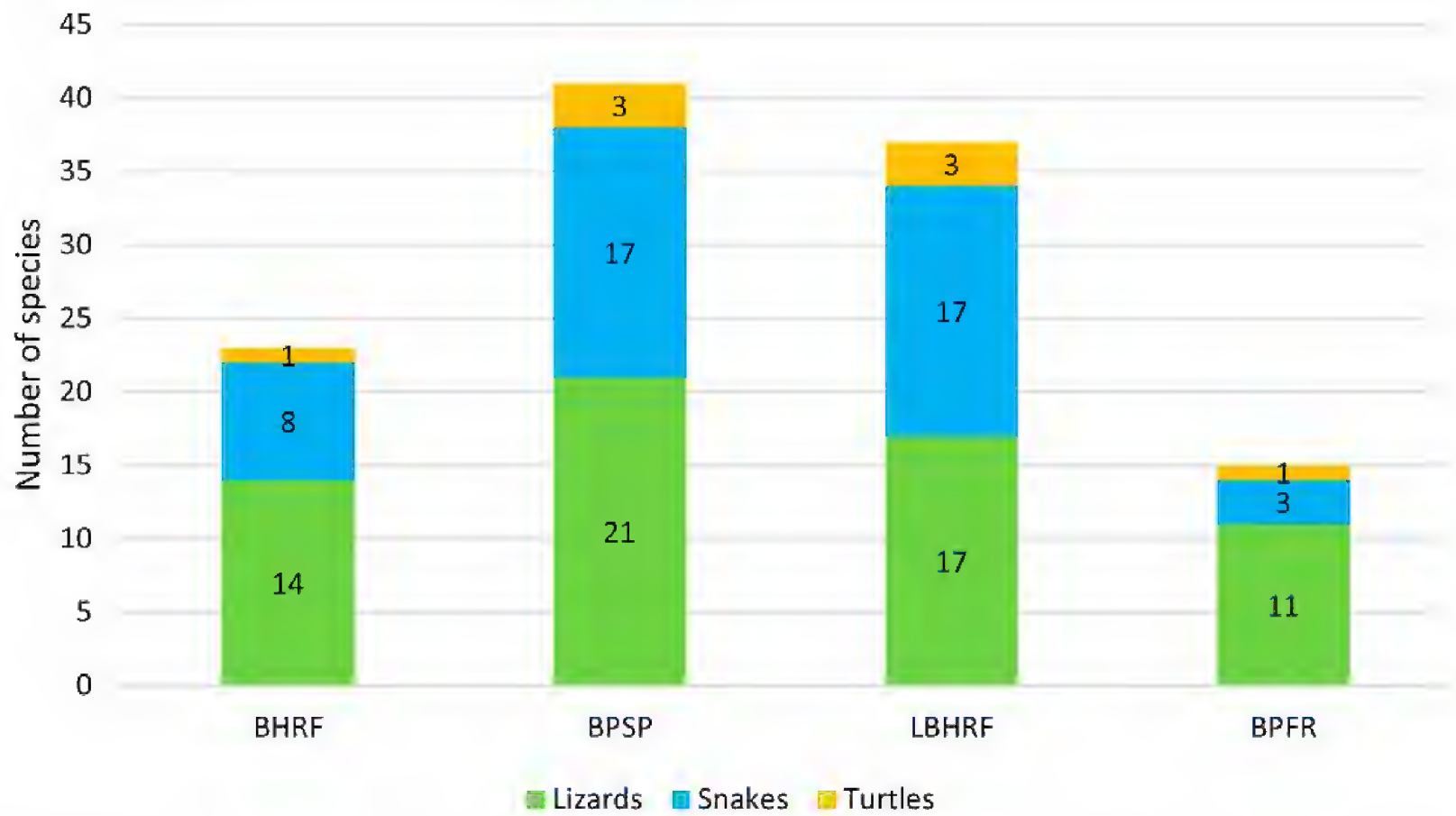

Figure 8. Number of reptile species for different taxa (lizards, snakes and turtles) recorded from BHRF, BPSP, LBHRF, and BPFR.

with BPSP, and 7 (31.82%) with BPFR (Table 2). Batu Hampar Recreational Forest shares the fewest number of species in common with BPFR, possibly due to differences in habitat and/or sampling effort. Based on the percentage of amphibian and reptile species shared between BHRF and other sites, it can be concluded that the herpetofaunal species composition of BHRF is moderately similar to that of nearby sites in the northwestern region.

Discussion

Herpetofauna assemblage at Batu Hampar Recreational Forest. Some of the frog species found are human commensal species, and their presence is always associated with disturbed habitats (Inger 2005). The presence of these species demonstrates that the habitat at BHRF is slightly disturbed, and this is evident by the presence of oil palm estates and other agricultural disturbances fringing the outskirts of the area. In addition, manmade structures like concrete pathways, huts, and other buidings are also found at BHRF, and trash from picnicking activities was commonly observed along the forest trail. The commensal species found at BHRF are *Fejervarya limnocharis*, *Microhyla heymonsi*, and *Polypedates leucomystax* (Shahriza and Ibrahim 2014a). Other species recorded are forest frogs, such as *Ingerophrynus parvus*, *Limnonectes blythii*, and *Leptobrachium hendricksoni* (Shahriza and Ibrahim, 2014a). *Odorrana hosii* and *Phrynoidis asper* are clean-water species that are associated with clear and fast-moving rocky streams (Dijk et al. 2004; Ibrahim et al. 2012), habitat which is present at BHRF. *Odorrana hosii* is a commonly observed frog species at BHRF. Most of the individuals were spotted while perched on rocks, vegetation, and the ground along the stream and along the trail to the dam area at night.

Based on our observation, *Gonocephalus grandis* was the most common agamid species at BHRF, where it was usually spotted sleeping on vegetation fringing the stream at night. Four out of the six reported gecko species (*Gehyra mutilata*, *Gekko monarchus*, *Hemidactylus frenatus*, and *H. murrayi*) are also human commensals and most commonly observed on manmade structures where they were found crawling on the walls of empty buildings at BHRF along the forest edges, while the other two species, *Cyrtodactylus consobrinus* and *Gekko kuhli*, were found in the forest. *Tropidolaemus wagleri* is the most commonly observed snake found at BHRF. In a single night on 8 October 2018, three female *T. wagleri* were spotted along the trail after heavy rains in the late afternoon. They might have been ambushing frogs that were more active after the rain (Tan et al. 2017).

The calculated species evenness of herpetofauna at BHRF is quite high with evenness index of 0.811. However, this does not represent the actual evenness of species in BHRF, as some individuals may have gone unnoticed and some of the frog species were heard calling along the trails, but we were not able to spot the calling individuals. This might cause discrepancies in the calculated species evenness from the actual species evenness. Continuous surveys are needed to monitor the species composition and their populations at BHRF to get a better understanding of its herpetofaunal diversity.

The reason for the higher species reported at BPSP might be due to the multiple, repeated surveys that have been carried out at BPSP and new species were recorded during each survey (Shahrul Anuar et al. 2006; Nur Hafizah 2011; Quah et al. 2013). The limited sampling period at BHRF is the main reason fewer species were found, as only seven sampling trips were carried out over a six month period compared to other sites where the surveys were conducted over longer periods. Besides that, sampling efforts at BHRF were focused more towards night time surveys which might have resulted in some diurnal species going unnoticed at night. The limited

Table 1. Checklist of the amphibians from Batu Hampar Recreational Forest, Bukit Panchor State Park (Quah et al. 2013), Lata Bukit Hijau Recreational Forest (Shahriza et al. 2011), Ulu Paip Recreational Forest (Shahriza and Ibrahim 2014b), Bukit Perangin Forest Reserve (Ibrahim et al. 2012), Bubu Permanent Forest Reserve (Ibrahim et al. 2011), and Bukit Jana (Shahriza and Ibrahim 2012).

Taxa	Batu Hampar (This study)	Bukit Panchor	Lata Bukit Hijau	Ulu Paip	Bukit Perangin	Bubu	Bukit Jana
CAECILIANS							
Ichthyophiidae							
Ichthyophis nigroflavus Taylor, 1960					X		
FROGS							
Bufonidae							
Ansonia malayana Inger, 1960						X	
Duttaphrynus melanostictus (Schneider, 1799)		X		X	X		X
Ingerophrynus parvus (Boulenger, 1887a)	X	X	X	X	X	X	X
Leptophryne borbonica (Tschudi, 1838)						X	
Phrynoidis asper (Gravenhorst, 1829)	X	X	X	X	X	X	X
Rentapia flavomaculata Chan, Abraham & Badli-Sham, 2020				X		X	
Dicroglossidae							
Fejervarya cancrivora (Gravenhorst, 1829)		X		X	X		X
Fejervarya limnocharis (Gravenhorst, 1829)	X	X	X	X		X	X
Hoplobatrachus rugulosus (Wiegmann, 1834a)		X		X			
Limnonectes blythii (Boulenger, 1920)	X	X	X	X		X	X
Limnonectes deinodon Dehling, 2014	X	X		X		X	X
Limnonectes hascheanus (Stoliczka, 1870)	X	X					
Limnonectes utara Matsui, Belabut & Ahmad, 2014						X	
Limnonectes malesianus (Kiew, 1984)		X				X	X
Limnonectes paramacrodon (Inger, 1966)			X	X			
Limnonectes plicatellus (Stoliczka, 1873)	X	X					X
Phrynoglossus martensii (Peters, 1867)	X	X		X			
Phrynoglossus sumatranus (Peters,1877)		X		X	X	X	X
Megophryidae							
Leptobrachella heteropus (Boulenger, 1900a)						X	
Leptobrachium hendricksoni Taylor, 1962a	X	X	X	X	X	X	X
Megophrys nasuta (Schlegel, 1858)			X			X	X
Microhylidae							
Kaloula pulchra Gray, 1831a		X					X
Microhyla butleri Boulenger, 1900a		X	X	X			X
Microhyla heymonsi Vogt, 1911	X	X	X	X			X
Microhyla mukhlesuri Hasan, Islam, Kuramoto, Kurabayashi & Sumida, 2014	X	X					X
Ranidae							
Amolops larutensis (Boulenger, 1899)			X			X	X
Hylarana banjarana (Leong & Lim, 2003)						X	
Hylarana erythraea (Schlegel, 1837a)		X	X	X		X	X
Hylarana glandulosa (Boulenger, 1882)		X		X	X		X
Hylarana labialis (Boulenger, 1887a)	X	X	X	X	X	X	X
Hylarana laterimaculata (Barbour & Noble, 1916)		X		X			
Hylarana malayana (Sheridan & Stuart, 2018)					X	X	
Hylarana nicobariensis (Stoliczka, 1870)			X	X	X	X	
Hylarana sundabarat (Chan, Abraham, Grismer & Brown, 2020c)			X		X	X	X
Odorrana hosii (Boulenger, 1891a)	X		X		X	X	X
Odorrana monjerai (Matsui & Jaafar, 2006)					X		
Rhacophoridae							
Nyctixalus pictus (Peters, 1871)		X					
Philautus larutensis (Boulenger, 1900b)						X	
Polypedates leucomystax (Gravenhorst, 1829)	X	X	X	X	X	X	X
Polypedates macrotis (Boulenger, 1891b)							X
Rhacophorus sp.						X	
Rhacophorus prominanus Smith, 1924						X	

Table 2. Checklist of the reptiles from Batu Hampar Recreational Forest, Bukit Panchor State Park (Quah et al. 2013), Lata Bukit Hijau Recreational Forest (Shahriza and Ibrahim 2014b), and Bukit Perangin Forest Reserve (Ibrahim et al. 2012).

Taxa	Batu Hampar (This study)	Bukit Panchor	Lata Bukit Hijau	Bukit Perangin
LIZARDS				
Agamidae				
Aphaniotis fusca (Peters, 1864)	X	X	X	
Bronchocela cristatella (Kuhl, 1820)	X	X	X	
Calotes versicolor (Daudin, 1802a)	X	X	X	
Draco fimbriatus Kuhl, 1820		X		X
Draco formosus Boulenger, 1900a		X		
Draco melanopogon Boulenger, 1887b			X	X
Draco sumatranus Schlegel, 1844 in Schlegel, 1837a		X		
Gonocephalus bellii (Duméril & Bibron, 1837)		X		
Gonocephalus grandis (Gray, 1845)	X		X	
Gekkonidae				
Cyrtodactylus bintangrendah Grismer, Wood Jr, Quah, Anuar, Muin Sumontha, Ahmad, Bauer, Wangkulangkul, Grismer & Pauwels, 2012		X		
Cyrtodactylus consobrinus (Peters, 1871)	X		X	
Cyrtodactylus macrotuberculatus Grismer & Ahmad, 2008				X
Cyrtodactylus payacola Johnson, Quah, Shahrul, Muin, Grismer, Wood, Chan, Greer, Grismer & Bauer, 2012		X		
Cyrtodactylus quadrivirgatus Taylor, 1962b		X	X	
Gehyra mutilata (Wiegmann, 1834b)	X	X	X	X
Gekko cicakterbang Grismer, Wood, Grismer, Quah, Thy, Phimmachak, Sivongxay, Seateun, Stuart, Siler, Mulcahy, Anamza & Brown, 2019				X
Gekko kuhli (Stejneger, 1902)	X		X	
Gekko monarchus (Schlegel, 1836) in Duméril & Bibron, 1836	X	X	X	X
Gekko smithii Gray, 1842		X	X	
Hemidactylus craspedotus Mocquard, 1890		X		
Hemidactylus frenatus Duméril & Bibron, 1836	X	X	X	X
Hemidactylus murrayi Gleadow, 1887	X			X
Hemidactylus platyurus (Schneider, 1797)		X	X	
Hemiphyllodactylus typus Bleeker, 1860		X		
Scincidae				
Dasia olivacea Gray, 1839		X		
Eutropis macularia (Blyth, 1853)	X			X
Eutropis multifasciata (Kuhl, 1820)	X		X	X
Sphenomorphus scotophilus (Boulenger, 1900c)	X*	X	X	
Sphenomorphus stellatus (Boulenger, 1900a)			X	
Varanidae				
Varanus rudicollis (Gray, 1845)		X		
Varanus salvator (Laurenti, 1768)	X	X	X	X
SNAKES				
Colubridae				
Ahaetulla mycterizans (Linnaeus, 1758)			X	
Ahaetulla prasina (Boie, 1827)		X		
Boiga cynodon (Boie, 1827)		X		
Boiga melanota (Boulenger, 1896)	X		X	
Chrysopelea ornata (Shaw, 1802)		X	X	
Coelognathus flavolineatus (Schlegel, 1837b)			X	
Coelognathus radiatus (Boie, 1827)			X	
Dendrelaphis formosus (Boie, 1827)			X	
Dendrelaphis pictus (Gmelin, 1789)			X	
Dryophiops rubescens (Gray, 1834)		X		
Gonyosoma oxycephalum (Boie, 1827)	X			
Oligodon purpurascens (Schlegel, 1837b)	X			
Rhabdophis chrysargos (Schlegel, 1837b)				X
Rhabdophis flaviceps (Duméril, Bibron & Duméril, 1854)		X		
Ptyas korros (Schlegel, 1837b)			X	
Xenochrophis trianguligerus (Boie, 1827)		X	X	

Taxa	Batu Hampar (This study)	Bukit Panchor	Lata Bukit Hijau	Bukit Perangin
Elapidae				
Bungarus candidus (Linnaeus, 1758)	X			
Bungarus flaviceps (Reinhardt, 1843)			X	
Naja kaouthia Lesson, 1831		X	X	
Naja sumatrana Müller, 1887				X
Ophiophagus hannah (Cantor, 1836)		X	X	
Homalopsidae				
Enhydris enhydris (Schneider, 1799)			X	
Homalopsis buccata (Linnaeus, 1758)	X	X	X	
Hypsiscopus plumbea (Boie, 1827)		X		
Pseudaspididae				
Psammodynastes pictus Günther, 1858		X		
Psammodynastes pulverulentus (Boie, 1827)		X		
Pareidae				
Aplopeltura boa (Boie, 1828)	X	X		
Pareas carinatus (Boie, 1828)		X		
Pythonidae				
Malayopython reticulatus (Schneider, 1801)		X	X	X
Viperidae				
Calloselasma rhodostoma (Kuhl, 1824)	X		X	
Tropidolaemus wagleri (Boie, 1827)	X	X	X	
Xenopeltidae				
Xenopeltis unicolor (Reinwardt, 1827) in Boie, 1827		X		
TURTLES				
Geoemydidae				
Cuora amboinensis (Daudin, 1802b)		X	X	
Heosemys spinosa (Gray, 1831b)		X	X	X
Trionychidae				
Dogania subplana (Geoffroy, 1809)	X	X	X	

*Unconfirmed species.

accessible areas at BHRF such as the narrow strip of forest along the stream as far as the dam area also reduced the chance to encounter more species compared to the wider areas at the other locations. The fewer types of microhabitats present at BHRF could also be one of the reasons that fewer species were found compared to some other locations that have a few different types of habitats, which in turn can support a greater assemblage of species. For example, there are swamps, streams, pools, forest, and granite boulder caves present at BPSP (Quah et al. 2013), versus forest, stream, and puddles at BHRF.

All amphibians recorded from each site were anurans except at BPFR, where a single species of caecilian (*Ichthyophis nigroflavus*) was recorded. Three species of flying lizards (*Draco fimbriatus*, *D. formosus*, and *D. sumatranus*) were recorded from BPSP, one species (*D. melanopogon*) from LBHRF and two species (*D. fimbriatus* and *D. melanopogon*) from BPFR. However, there were no flying lizards found at BHRF, despite BHRF containing similar habitat. This might be due to the diurnal habits of flying lizards and their cryptic colouration that make them inconspicuous, especially during night time surveys. Besides that, some diurnal and arboreal snake species such as *Ahaetulla prasina* and *Dendrelaphis pictus* were found at some other sites but not at BHRF. The low number of snake species found at BHRF might be due to a combination of their behaviour and appearance, as well as the limited sampling period. The secretive and elusive behaviour of snakes make them easily unnoticed and most will quickly flee upon human approach. The colour pattern of some species camouflages them well, which also makes them less conspicuous (Ibrahim et al. 2013; Shahriza and Ibrahim 2014b).

Taxonomic changes since publication of checklists for BPSP, UPRF, BPFR, BBPFR, and BJ. Since the publication of the various checklist of other nearby locations, a number of taxa reported from those sites have undergone taxonomic revision. The systematic changes are discussed below.

Rentapia flavomaculata from UPRF and BBPFR were reported as *Pedostibes hosii* by Shahriza and Ibrahim (2014a) and Ibrahim et al. (2011). This species was formerly placed in the genus *Pedostibes* which previously consisted of five species found in India (2 species) and Southeast Asia (3 species) (Inger 1966; Dinesh and Radhakrishna 2013; Frost 2019). Chan et al. (2016) demonstrated that these species are not only geographically isolated, but the species from Southeast Asia also have very different morphologies and modes of reproduction compared to those from India. As a result, Chan et al. (2016) placed the three Southeast Asian species (*P. hosii*,

P. rugosus and *P. everetti*) into a new genus, *Rentapia*, restricting *Pedostibes* to India. Besides that, the study also found that *R. hosii* could be a species complex which consists of multiple endemic lineages (Chan et al. 2016). By conducting morphological and bioacoustic analyses, Chan et al. (2020a) showed that populations of *R. hosii* from Peninsular Malaysia are different from the Bornean populations. Hence, the populations from Peninsular Malaysia were described as a new species, *R. flavomaculata*, and the authors restricted *R. hosii* to Borneo (Chan et al. 2020a).

Populations of *Limnonectes laticeps* (currently synonymized with *L. khasianus*) from Peninsular Malaysia and reported from BPSP, UPRF, BBPFR, and BJ, have been reassigned to the recently described *L. deinodon* (Dehling 2014). Based on Dehling (2014), the populations from the Thai-Malay Peninsular have unique morphological characteristics and different advertisement calls that separate them from *L. khasianus*.

Limnonectes utara reported from BBPFR was formerly identified as *L. kuhlii*. In 2014, Matsui et al. (2014) investigated the phylogenetic relationship of *L. kuhlii* and showed that the individuals from Peninsular Malaysia formed a monophyletic group which diverged into two lineages, a northern (*L. utara*) and a southern (*L. selatan*) clade. Based on the geographic proximity of the *L. kuhlii* reported from BBPFR to the type locality of *L. utara* at Bukit Larut, we assign that population to *L. utara* instead of *L. selatan*.

Microhyla mukhlesuri from BJ and BPSP was reported as *Microhyla fissipes* by Shahriza and Ibrahim (2012) and Quah et al. (2013). According to Yuan et al. (2016), the populations of *M. fissipes* are divided into two lineages that are separated by the Red River of China and Vietnam. *Microhyla fissipes* is restricted to the regions northeast of the Red River, including Hainan and Taiwan. The populations southwest of the Red River have been shown to be *M. mukhlesuri*, which ranges throughout Indochina, westward to Eastern Bangladesh and southward to Thailand, Peninsular Malaysia and Singapore (Yuan et al. 2016).

Ibrahim et al. (2011) reported *Rhacophorus bimaculatus* from BBPFR, which is listed as *Rhacophorus sp.* in Table 1. Based on Gonzalez et al. (2014), *R. bimaculatus* is restricted to the Philippines and does not occur in Peninsular Malaysia. The specimen reported at BBPFR might be a misidentification of *R. cyanopunctatus* as the location is a lowland site and this eliminates the possibility of it being *R. rhodopus* (*R. bipunctatus*) (Chan et al. 2018), which is a montane species.

Limnonectes doriae was reported by Ibrahim et al. (2011) from BBPFR. However, this species is no longer recognized as part of the amphibian fauna of Peninsular Malaysia based on Chan et al. (2010).

Phrynoglossus martensii reported from BHRF, BPSP, and UPRF, and *P. sumatranus* reported from BPSP, UPRF, BPFR, BBPFR, and BJ were previously placed in the genus *Occidozyga*, and *Phrynoglossus* was considered a synonym of *Occidozyga*. Köhler et al. (2021) conducted phylogenetic, morphological and bioacoustics analyses and found that some species previously placed in the genus *Phrynoglossus* can be distinguished from *Occidozyga*. Hence, they recognized *Phrynoglossus* as a valid genus and returned these species to *Phrynoglossus* (Köhler et al. 2021).

Hylarana sundabarat reported from LBHRF, BPFR, BBPFR, and BJ were previously reported as *H. picturata*. All previous records of *Hylarana* or *Pulchrana picturata* and *P. signata* from Peninsular Malaysia are now recognized as *H. sundabarat*, based on the works of Chan et al. (2020b, 2020c) that demonstrated that populations of *H. picturata* from Peninsular Malaysia and Sumatra are not only genetically different from the Bornean population, but also differed morphologically and in bioacoustics. *Hylarana picturata* is now restricted to Borneo (Chan et al. 2020c). Chan et al. (2020c) had described *H. sundabarat* as *P. sundabarat*. However, *Pulchrana* is now synonimized with *Hylarana* according to Dubois et al. (2021).

Populations of *Hylarana nigrovittata* from Peninsular Malaysia including those reported from BPFR and BBPFR have been reassigned to the recently described *H. malayana* (Sheridan and Stuart 2018). *Hylarana malayana* ranges from southern Myanmar and Thailand, and southward to Peninsular Malaysia, while *H. nigrovittata* ranges from Thailand, westward to eastern Myanmar and northward to northern Laos and northern Vietnam (Sheridan and Stuart 2018). Sheridan and Stuart (2018) had described *H. malayana* as *Sylvirana malayana*. However, *Sylvirana* is now synonimized with *Hylarana* according to Dubois et al. (2021).

Philautus larutensis from BBPFR was previously reported as *P. petersi*. Based on the study by Wostl et al. (2017), the populations from Sumatra, Borneo and Peninsular Malaysia have high genetic divergence and morphological differences from the population on Great Natuna Island. As a result, they resurrected *P. larutensis* from the synonymy of *P. petersi*, and that nomen is now applied to the populations from Sumatra, Borneo and Peninsular Malaysia. *Philautus petersi* is restricted to Great Natuna Island (Wostl et al. 2017).

Cyrtodactulus bintangrendah from BPSP was previously classified as *C. pulchellus* and has been described as a different species by Grismer et al. (2012). *Cyrtodactylus pulchellus* is endemic to Penang Island (Grismer et al. 2012).

Gekko cicakterbang reported from BPFR was previously recognized as *Ptychozoon lionotum* by Ibrahim et al. (2012). The species from the genus *Ptychozoon* are nested within the genus *Gekko* based on Wood et al. (2020), and *Ptychozoon* is now recognized as a subgenus. Grismer et al. (2019a) described the population of *G. lionotum* from Peninsular Malaysia as a new species, *G. cicakterbang*. *Gekko lionotum* is now restricted to populations from northwestern Laos through southern Myanmar and westwards to eastern India (Grismer et al. 2019a).

Populations of *Hemidactylus murrayi* from Peninsular Malaysia and reported from BHRF and BPFR was previously known as *H. brookii*. In 2016, Lajmi et al. investigated the phylogenetic relationships of *H. brookii* complex and found that it consist of multiple deeply divergent clades with high genetic differences between the clades. Through morphological analysis, individuals from one of the clade (clade 4) match the description of *H. murrayi* by Gleadow (1887). Hence, individuals from this clade, which include individuals from Peninsular Malaysia is now recognized as *H. murrayi* (Lajmi et al. 2016).

Boiga dendrophila from Peninsular Malaysia and reported from BHRF and BPFR was previously recognized as a subspecies, *Boiga dendrophila melanota*. Based on a phylogenetic study by Weinell et al. (2020), *B. d. melanota* is more closely related to *B. tanahjampeana*, a species endemic to Sulawesi, than to other subspecies of *B. dendrophila*. As a result, *B. d. melanota* is elevated to full species rank and is now recognized as *B. melanota* (Weinell et al. 2020).

Rhabdophis flaviceps from BPSP was previously reported as *Macropisthodon flaviceps* by Quah et al. (2013). Species of the genus *Macropisthodon* are now synonymized with *Rhabdophis* according to the study by Takeuchi et al. (2018), as members of the genus *Macropisthodon* were nested well within *Rhabdophis* in their phylogenetic analysis.

Hypsiscopus plumbea reported from BPSP was previously recognized as *Enhydris plumbea* (Quah et al. 2013). Because numerous studies had shown that *Enhydris* was polyphyletic, many of its former members were reclassified based on molecular and morphological analyses (Murphy and Voris 2014). In the case of *Enhydris plumbea*, it was allocated to the genus *Hypsiscopus*.

Malayopython reticulatus was previously reported as *Broghammerus reticulatus* (BPSP) and *Python reticulatus* (BPFR, LBHRF). We follow the taxonomy of Reynolds et al. (2014) that places the species in the new genus, *Malayopython*.

Conclusion. The herpetofaunal diversity of Peninsular Malaysia is still underestimated as many new species continue to be discovered every year (Chan et al. 2018; Grismer et al. 2017, 2018, 2019b; Quah et al. 2020b). More surveys and research on the country's herpetofauna should be conducted in order to have a better understanding of their diversity and distributions so that efficient and effective conservation strategies can be developed and implemented.

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Authors' Contributions

HZ conducted field work, preparation, cataloguing and identification of specimens, and wrote the manuscript. EQSH assisted with fieldwork, preparation, identification of specimens, and contributed to the writing and revision of the manuscript. SA obtained the permits and funding for the study and assisted with the writing and editing of the manuscript. LLG contributed to the writing and revision of the manuscript.

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